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Studies in the Estimation of Elasticities of U.S. Army Recruit Production Factors

by

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April 1996

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The United States military recruiting commands are tasked with providing new recruits in sufficient numbers, of the correct types, to maintain the national defense. To accomplish this they are authorized by Congress to advertise and to offer certain incentives to attract eligible persons into the required billets. These programs involve costs and, with increasingly severe budget restrictions, it is important that the dollars available be spent in the best possible manner. A number of fairly recent studies have attempted to estimate the relative effects of advertising and various other incentives on the production of enlisted contracts. This paper discusses some issues involved in such estimation, reviews the data used in one recent study, and employs this data to estimate several alternative models of contract production. Recommendations are made about collecting and maintaining accurate data for the investigation of tradeoffs of resource allocations.

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Studies in the Estimation of Elasticities of U.S. Army Recruit Production Factors

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Executive Summary

The United States military recruiting commands are tasked with providing new recruits in sufficient numbers, of the correct types, to maintain the national defense. To accomplish this they are authorized by Congress to advertise and to offer certain incentives to attract eligible persons into the required billets. These programs involve costs and, with increasingly severe budget restrictions, it is important that the dollars available be spent in the best possible manner. A number of fairly recent studies have attempted to estimate the relative effects of advertising and various other incentives on the production of enlisted contracts. This paper discusses some issues involved in such estimation, reviews the data used in one recent study, and employs this data to estimate several alternative models of contract production. Recommendations are made about collecting and maintaining accurate data for the investigation of tradeoffs of resource allocations.

I. Background

The discontinuance of the draft placed the armed services in a new posture relative to the acquisition of labor. The requirement for quality recruits at reasonable cost led to the formalized study of the appropriate labor supply, the ability to tap that supply in adequate numbers, and the measurement of the job performance of those that join the services [16]. The present study is follow on work to that found in [4], which deals with the issues of acquiring high quality recruits in a timely fashion and at reasonable costs.

For recruiting purposes, high quality recruits are defined as males in the 17-21 age group who either are high school seniors or graduates and have scored well on the Armed Forces Qualification Test (AFQT, categories I-IIIa). The Army is allowed to offer a number of incentives to help in the acquisition of recruits (especially the high quality recruits); these currently include monetary incentives (bonuses) of various types, support for attending college after service and the repayment of previously contracted college loans. In addition, the Army is allowed funds for various advertising efforts and for experienced recruiters to make personal contact with prospective enlistees. These factors are used in measured degrees to aid the achievement of the current goals (also called missions or quotas), set by the Department of the Army, for recruits in the various specialties and to overcome the offsetting effects of the economy and competing opportunities in the civilian world.

Reference [20] contains modeling appropriate to the relations between the inputs and outputs of this process, utilizing the elasticities of the high quality recruits with respect to the several variables at the disposal of the recruiting commands. Thus the estimation and temporal stability of these elasticities is an important issue in this process. The effects of uncontrollable factors, such as unemployment, competing civilian wages, and social attitudes, need to be accounted for (or removed from) the estimation of these elasticities to the greatest extent possible.

The present report deals with econometric modeling and the estimation of elasticities. More specifically the work of Berner & Daula [4] has been specified as a point of departure. They have graciously shared the data used in their report for this effort. The model structure presented in their report has been altered, the techniques of specific model development have been enhanced, and more recent data are being gathered to investigate possible changes to the elasticities required to use the structure of [20]. In this regard, new data on the numbers of recruits contracted and on the various benefits available to them for the latter part of the period covered by the Berner & Daula data is currently available. These values have been used, for this shorter time period, to re-estimate several elasticities of interest, using a model from the recent econometric literature which allows for varying efficiency levels among groups (battalions for our application).

Our original intent was to gather more recent data than that used in [4], and to explore various models for estimating elasticities of interest using these later data values. The modelling was to employ the same variables as those used in [4], to the extent possible, to provide comparability with earlier efforts. The data gathering process has proved extremely time consuming and has not yet been completed. In the interim, necessary computer programming to implement the models chosen has been completed.

The data currently available are briefly described in Section II, and the structures of the new classes of models is also presented there. Some numerical results are presented in Section III, derived in part or in whole from the historical data set provided by Berner & Daula. Section IV contains some conclusions and is followed by an appendix that contains details and idiosyncrasies that may be useful to others interested in modelling in this area.

II. Data available and Structure of Models

The data set used in [4] contained monthly data on all of the Army's recruiting battalions (originally 56 in number, dropping to 55 during the period) for the time span from fiscal year 1981 (starting in October, 1980) through December, 1989 (the first three months of fiscal year 1990). The values of many variables were given; these include the numbers of high and low quality contracts produced, the goals for these types of contracts which the Army wanted to meet, the delayed entry program (DEP) losses which occurred, and money spent on advertising (of several types). In addition, the values for many incentive variables were given (bonuses, Army college fund), the values for basic military compensation were given, as well as estimates of the competing civilian wage; also included were indicators of the size of the eligible population (for recruiting), numbers of recruiters and indicators of how experienced they were, measures of the youth attitude toward the military as a career, and estimated unemployment rates. Some of these variables changed values monthly, some quarterly or less frequently, and some only annually. Similarly, some of them are constant across battalions and others vary with battalion. A more complete description of this data set, and some of its apparent weaknesses, is given in the Appendix.

In addition to the historical data set provided by Berner & Daula, the United States Army Recruiting Command (USAREC) has provided data on the numbers of enlisted contracts written and details of various benefit packages offered (primarily bonuses and future educational benefits) from fiscal year 1988 through fiscal year 1994. This period overlaps the final 27 months covered by the Berner & Daula data set; the USAREC data on contract production is in fair agreement with the values used by Berner & Daula for the same period. The USAREC data on benefits offered during this overlap period is considerably more detailed than the historical data and is not in apparent agreement with the values used in [4]. This fact would be expected to have a major impact on the estimated elasticities for such benefits. Unfortunately, it has not yet proved possible to get reliable later data on all the other variables used in the Berner & Daula study, so a complete study utilizing the same variables as [4] with more recent data is not currently feasible. However, Daula has proposed a different model for estimating the same elasticities; this suggestion has been investigated using the historical data set. In addition, a model proposed by Cornwell,

Schmidt and Sickles [6], an approach also recommended by Daula, has been investigated using the USAREC data on contracts and benefits, together with the historic data on other variables for the 27 months of overlap between the data sets.

The utility function introduced by Polich, Dertouzos, and Press [20] serves at the heart of the modeling used by Berner & Daula. They developed a multi-equation econometric system as a result of optimizing this utility function for each time period (month) of observation. The results of their system, coupled with a three regime partitioning, were reported in [4]. More recently, Daula has developed optimization equations for this utility function based upon a time window of several months or more. The result of his derivation has led to autoregressive modeling and is presented below.

In what follows, H_t represents the number of high quality contracts signed in period (month or quarter) t, QH_t represents the high quality goal for period t, L_t represents the number of low quality contracts (anything other than high), and $X_{1,t}$ represents the collection of exogenous variables used (unemployment rate, military compensation, civilian wage rate, various benefits available, qualified persons available in the market to be recruited, *etc.*) in period t. The variables H_t, QH_t, L_t were treated as being endogenous in [4]; Daula suggested maintaining this assumption with the newly specified model.

The basic equation which Daula suggested should be estimated from observed data is

$$\ln H_t = \alpha_1 \ln L_t + X_{1,t}\alpha_2 + \alpha_3 \ln QH_t + \alpha_4 \ln H_{t+1} + \alpha_5 \ln QH_{t+1} + \alpha_6 \sum_{j=1}^{\infty} \alpha_7^j \Delta_{t-j},$$

where

$$\Delta_{t-j} = \delta_1 \ln H_{t-j} - \delta_2 \ln L_{t-j} - X_{1,t-j}\delta_3 - \delta_4 \ln QH_{t-j} - \delta_5 \ln QH_{t+1-j}.$$

Note that this basic equation involves both positive (backward in time) and negative (forward in time) lags. It could be that $\alpha_4 = 0$ (high quality contracts in period t do not depend on those in period $t+1$) or $\alpha_5 = 0$ (no dependence on the goal in the following period) or both. These hypotheses could be tested using the observed data. This basic equation also employs infinite lags into the past, which of course is not feasibly estimable.

Daula further suggested this model be simplified by dropping all terms with $j \geq 2$. This then states that the log of the number of high quality contracts to be produced in period t is a function of the low quality contract production in the current period and the

one preceding, as well as the high goal in the preceding, current and succeeding periods, the number of high quality contracts in the preceding and succeeding periods, as well as the current value of any exogenous variables used (incentives, military and civilian pay, unemployment, youth attitudes, lagged endogenous variables, and so on).

To help control for battalion specific effects, the logs of all variables (except dummies) were computed and then centered at their battalion means (difference between the log and the grand mean of the logs over the full span of time). Simple two-stage least squares was suggested as the basic procedure to employ in estimating the unknown coefficients in the model. As has been mentioned, Berner & Daula used monthly data in [4] with their three-regime approach; this new equation was also estimated with monthly data, giving estimates which were not very stable (the estimated coefficients could change quite drastically if certain variables were added or deleted). Kearl and Schmitz [17] are experienced in modelling with this type of data and suggested that more stable results might be expected with quarterly data. This point has been investigated by aggregating the monthly data into quarterly values; the same model (employing the same exogenous variables) is more stable with the quarterly values from this historical data set. Schmitz [22] also suggested that the historic data set values for the bonus variables and educational benefits did not appear to match the values contained in an earlier report. He has provided the alternative (annual) values for these variables.

Some numerical results produced by this new model are presented in the next section. As with results quoted in [4], some of the elasticities produced have incorrect signs, even with quarterly data values; this is probably caused by the quality of the data itself. (See the appendix for a discussion of this historical data set.)

The approach taken by Cornwell, Schmidt and Sickles [6] includes the possibility of differing efficiency levels for the different battalions; this is done by essentially adopting a separate "y-intercept" for the various battalions which is a polynomial function of t, the time period (the same order is used for all battalions). The variables to be modelled are projected into the space orthogonal to such a polynomial intercept, then regular least squares regression is applied to estimate the unknown coefficients; finally, the residuals of this regression then are regressed on the desired polynomial function, providing the

estimates for the individual battalion y-intercepts.

This type of model has been investigated using the final 27 months of data for some of the historical data values used in [4]; the numbers of high and low contracts produced were those provided by USAREC. The data describing benefits offered (see Appendix for a description of their construction) were computed from the recently supplied USAREC data in the same spirit used by [4].

The historical data set included several variables describing enlistment bonuses:

- BONUS – Weighted average of the fraction of enlistees eligible for a bonus times the value of the bonus, where the weights were based on the average fractions of three year (.512) and four year (.412) enlistments over the full time span; adjusted by the CPI to 1990 dollars
- AVGBONUS – Weighted average of the three year and four year bonuses offered, presumably using the same weights as BONUS; adjusted to 1990 dollars.
- AVGBCOV – Weighted average of the fraction of soldiers eligible for a bonus, presumably again the same weights as used for BONUS.
- BON3 – Average bonus taken by a three year enlistee. Not known whether it was adjusted to constant 1990 dollars.
- COV3 – Fraction of three year enlistees who are eligible for the enlistment bonus.
- BONUS3 – Product BON3×COV3.

These variables were constant across battalions and changed at most quarterly, especially at the beginning of the period covered. During the final 27 months covered, BONUS and AVGBONUS each had 4 different values (shifting at the same times) while AVGBCOV had only 2 different values (.331 for FY88, .407 for FY89 and the first 3 months of FY90, missing for the remaining 9 months of FY90, as were the other two variables). Variables BON3 and COV3 each had three different values during these final 27 months, changing simultaneously. In addition, the data set included dummy variables indicating the enlistment bonus experiment period (July, 1982, through June, 1984), and the type of cell (control, $8,000 bonus or $4,000/$8,000 option) the battalion fell into for this experiment.

Similarly, the historical data base included several variables describing the educational benefits available; these included

- ACFCOV – Fraction of soldiers eligible for the Army college fund or other educational benefit.
- ACFPV – Present value of educational benefit available at time of enlistment, assuming three year enlistment, deflated by a cost of college price index, constant 1990 dollars.
- ACF – Product of the above two variables.

These variables were constant across battalions and changed at most with fiscal year; in

fact ACFCOV is constant at 0.63 from the start of FY86 through the end of the data set, while each of the other two take on 3 different values during the final 27 months (a different value for each fiscal year; for each of these the FY89 value is .936 times the FY88 value and the FY90 value is .936 times the FY89 value). In addition, the data set included a number of dummy variables associated with educational benefits; these were indicators for the educational benefit experiment (December, 1980 – September, 1981), for the Army College Fund with kicker, the Mini GI bill, and the non-contributory VEAP period.

The newly supplied USAREC data indicates 10 different intervals in the 27 months from October 1987 through December 1989 at which the enlistment bonus structure or the college benefit structure (or both) changed values. These data were used to construct equivalent variables to those provided in the historical data base, to the extent possible. According to this data set, there were no three year enlistment bonuses offered during this period; however, 4 year, 5 year and 6 year bonuses were offered. Thus the bonus variables created were based on these three lengths of time, rather than 3 year and 4 year bonuses as used in the historical data set.

III. Some numerical results

The major dependent variable to be modeled is the number of high quality contracts written per battalion in a time period. This variable is likely to be influenced by such internal environmental factors as the high and low quality quotas (or missions), the DEP losses, and the numbers of low quality contracts produced. The previously mentioned external environmental factors such as various competing wages available in the civilian market, cost of living and unemployment variables, the supply of desirable recruits and how they may be influenced by current attitudes toward the military, educational level, cultural group, and possibly other variables may also affect the number of high quality contracts achieved by a particular battalion in a particular time frame. Various production factors were applied in measured amounts; these include types of advertising, the cadre of recruiters and monetary incentives (enlistment bonuses, educational benefits).

While awaiting the compilation of the 1988 to 1994 data we organized software and wrote programs to support the new modeling and tested them using the Berner-Daula data

set from the decade of the 80's. The model fitting process takes a great deal of exploratory computation and diagnostic testing.

Generally the new models can achieve high levels of R^2, the square of the multiple correlation coefficient. However, we found that model building was unstable using monthly data. We were advised that we might get greater stability if we used quarterly data vice monthly data. This proved to be true. This is likely a result of the fact that so many of the exogenous variables change but quarterly or even less frequently. See Appendix A.

For illustrative purposes, we present some modeling results using quarterly data for the calculation of elasticities. The model is not polished and there are some diagnostic weaknesses, but they do exhibit stability in the sense that, generally, minor model changes lead to but modest changes in the coefficients. Natural logs of all non-dummy variables were computed; the battalion-month value for each such variable then was centered by expressing it as the deviation of the log value from the grand mean of its logs over the full span of months and battalions.

In what follows the endogenous variables are HIGH (number of high quality contracts signed), QH (high mission or quota), and LOW (number of low quality contracts signed). The Berner-Daula paper has evidence supporting the possibility that QH is endogenous, and assumed LOW to also be endogenous. The tables below contain summary information covering the process. Those variable names ending in M1 have been lagged backwards one period.

As mentioned earlier, Schmitz [20] provided alternative values for the bonus and educational variables; the variables ending in _S use his values, rather than the original values in the historic data set. DEPHI is the label for high quality DEP loss, UNEMP is adult unemployment, BONUS_S is a measure of the bonus (3-year and 4-year enlistments) available, BON3_S is the average 3-year bonus taken, BCOV is a weighted average fraction of enlistees eligible for an enlistment bonus, ACFCOV_S is the fraction of enlistees eligible for the Army college fund or other educational bonus, SBMC is a smoothed version of basic military compensation, TVAD is the dollar amount spent on national television advertising, ACFPF_S is the present value of educational benefits available to enlistees, in 1990 dollars, RECR is the number of active recruiters in the battalion, Q1 through Q4 are quarterly

dummy variables, QMA is the qualified military available, MIN is the minority proportion of QMA, and YATS is the fraction of the eligible population which looks favorably on the military as a career. While the data values provided by Schmitz do differ from their counterparts in the historic data set, the ultimate effect on the computed elasticities is quite minor.

Table 1

Two Stage Least Squares

Dependent variable: HIGH

Valid cases:	1755	Durbin-Watson:	1.9477
Total SS:	156.8562	Missing cases:	0
R^2:	.86	Degrees of freedom:	1737
Residual SS:	21.9622	Std error of est:	0.1124

Variable	Coefficient	Standard Error	t-Statistic	p-Value
DEPHI	0.0637	0.0105	6.0667	0.0000
QH	0.2969	0.0446	6.6591	0.0000
UNEMP	0.2395	0.0220	10.8824	0.0000
BONUS_S	−0.0038	0.0017	−2.2458	0.0248
BON3_S	0.0010	0.0107	0.0973	0.9225
BCOV	0.0315	0.0505	0.6250	0.5321
ACFCOV_S	−0.2323	0.0473	−4.9068	0.0000
SBMC	−0.3696	0.1816	−2.0347	0.0420
TVAD	0.1235	0.0629	1.9634	0.0498
ACFPV_S	0.2141	0.0457	4.6832	0.0000
RECR	0.1946	0.0353	5.5103	0.0000
HIGHM1	0.3316	0.0258	12.8541	0.0000
DEPHIM1	−0.0181	0.0084	−2.1472	0.0319
LOW	0.0575	0.0662	0.8683	0.3853
Q1	−0.0102	0.0071	−1.4471	0.1480
Q2	0.0400	0.0061	6.5558	0.0000
Q3	−0.0764	0.0066	−11.4862	0.0000
Q4	0.0466	0.0091	5.1482	0.0000

In the Two Stage Least Squares model described in Table 1, the actual values of the other endogenous variables (QH and LOW) are not used; instead each endogenous variable is regressed on a set of exogenous variables, and the fitted values from these regressions are employed. For completeness, the analyses of variance for these two fitted models are given

Table 2
Ordinary Least Squares
Dependent variable: QH

Valid cases:	1755	Durbin-Watson:	1.9337
Total SS:	201.9052	Missing cases:	0
R^2:	.76	Degrees of freedom:	1745
Residual SS:	47.5165	Std error of est:	0.1650

Variable	Coefficient	Standard Error	t-Statistic	p-Value
DEPHI	0.0176	0.0094	1.8809	0.0602
DEPHIM1	0.0296	0.0090	3.2737	0.0011
ACFCOV_S	−0.0091	0.0023	−3.9523	0.0001
QMA	0.4290	0.0849	5.0523	0.0000
QHM1	0.3994	0.0208	19.1639	0.0000
HIGHM1	0.3742	0.0257	14.5575	0.0000
Q1	−0.0795	0.0083	−9.6004	0.0000
Q2	0.0587	0.0080	7.3153	0.0000
Q3	−0.1019	0.0082	−12.3758	0.0000
Q4	0.1225	0.0082	15.0041	0.0000

in Tables 2 and 3.

Even with the quarterly data, some of the elasticities for the benefit variables are negative; this problem also occurred for the model in [4].

As mentioned in section II, new data on contracts signed and benefits offered has been provided by USAREC for fiscal years 1988 through 1994. This allows comparison of the historical values used in [4] with the current best records for the period from October, 1987, through December, 1989. This new data provided by USAREC generally gives lower values for contracts produced (of both low and high quality) than are recorded in the historic data base; see the appendix for more information on the comparison of the two records of contracts produced.

The USAREC data on benefits offered includes much more detail than the historic data set. New bonus variables were constructed from this USAREC data, using the descriptions from the historic data set. These differ considerably from the values used in [4]; the appendix details the method of construction for these variables.

The variable measuring Army college fund coverage, in the historic data base, was

Table 3
Ordinary Least Squares
Dependent variable: LOW

Valid cases:	1755	Durbin-Watson:	2.0473
Total SS:	113.6493	Missing cases:	0
R^2:	.67	Degrees of freedom:	1743
Residual SS:	37.8863	Std error of est:	0.1474

Variable	Coefficient	Standard Error	t-Statistic	p-Value
HIGHM1	0.1188	0.0233	5.0972	0.0000
TVAD	−0.5601	0.0469	−11.9306	0.0000
RECR	0.2635	0.0411	6.4038	0.0000
MIN	−0.0695	0.0975	−0.7126	0.4762
YATS	0.0419	0.0226	1.8515	0.0643
LOWM1	0.4496	0.0202	22.2599	0.0000
NADV	0.6045	0.0525	11.5109	0.0000
UNEMPM1	0.0963	0.0247	3.8962	0.0001
Q1	−0.0851	0.0074	−11.5796	0.0000
Q2	0.0943	0.0071	13.2266	0.0000
Q3	−0.0828	0.0073	−11.2747	0.0000
Q4	0.0734	0.0073	10.1120	0.0000

constant at .63 for the final five years worth of data, whereas the Army college fund present value variable changed with fiscal year and had 3 values in these final 27 months. The variable constructed from the USAREC data, meant to measure the same coverage, was based only on the high quality contracts produced; see the appendix for details of its construction. Since we did not have access to the actuarial rates used to construct the Army College Fund Present Value variable, no attempt was made to create comparable values from the USAREC data.

An alternative model proposed by Cornwell *et al* [6] has been programmed and employed to investigate elasticities for this 27 month period of overlap between the historic data set and the newly provided data. This model has the advantage that it presumably allows estimation of (and provides correction for) varying levels of efficiency in use of resources across battalions. This uses data from both the historic data set and recent USAREC data. The efficiency factors are captured by individual quadratic time effects for the battalions. The historic data set included at least partial data for 56 battalions

over the period October, 1980, through December, 1989; the San Juan battalion data was not used, reducing the number of battalions to 55. The Fort Monmouth battalion was disestablished at the end of FY88, having only one year of data for the 27 months studied; it was also deleted in using this model, leaving 54 battalions with useable data. This resulted in $54 \times 27 = 1458$ monthly data values for the model. Allowing for the possibility of lagging one period (both positively and negatively), the actual number of monthly data points available is reduced to $54 \times 25 = 1350$. The numbers of contracts signed, for both high and low quality recruits, were the recent values provided by USAREC; the variables for educational benefits and enlistment bonuses were also constructed from this new data set. The other variables used came from the historic data set.

In modeling the production of high quality contracts over this period, the possible endogeneity of the high quality goals and the low quality contracts was allowed for by replacing these variables by instruments to get consistent elasticity estimates; to investigate the effects of this assumption, the corresponding model using these variables themselves was also estimated. The following tables present some typical results of this modeling with the monthly data.

Assuming that QH and LOW are endogenous (Table 4), it would appear that neither is significant; with neither endogenous, (Table 5) they are both quite significant, but the sign for LOW is not sensible (increasing the number of low contracts should, if anything, decrease the number of high contracts produced). In both tables, the proportion of advertising dollars spent on advertising (TVAD/NADV) has a significant negative coefficient, which is surely incorrect; recall that the various advertising variables change but infrequently (and are quite possibly not accurate) in the historical data set; even if the values are accurate, their crude representation has quite possibly introduced problems of multicollinearity, causing inaccuracy in estimation of the coefficient. (The same is true for the amount spent on advertising NADV.) The coefficients for the remaining variables are at least plausible; those for the bonus and college fund incentives are positive, with the college fund coefficient being larger. This relationship holds across a large number of different particular models which have been fit to this final 27 months of data. Recall that the recent USAREC data is not in good agreement with the historical data for either bonuses

Table 4

Cornwell Model – Instruements for QH, LOW

Dependent variable: HIGH (USAREC)

Valid cases:	1350	Durbin-Watson:	1.984
Total SS:	37.636	Missing cases:	0
R^2:	.337	Degrees of freedom:	1336
Residual SS:	24.964	Std error of est:	0.138

Variable	Coefficient	Standard Error	t-Statistic
QH	0.3713	0.5545	0.670
LOW	−0.0463	0.1235	−0.375
DEPHI	0.0341	0.0205	1.661
BCOV(USAREC)	0.4235	0.0836	5.064
ACFCOV(USAREC)	0.5537	0.1495	3.703
RELW	0.0020	0.0017	1.185
TVAD/NADV	−0.1065	0.0340	−3.131
NADV	0.1815	0.9703	0.187
RECR	0.4438	0.1105	4.016
HIGHM1	−0.2535	0.0684	−3.708
DEPHIM1	0.0389	0.0439	0.887
Q1	−0.0824	0.0933	−0.884
Q2	−0.0373	0.1129	−0.330
Q3	−0.1739	0.0355	−4.905

or educational benefits; the earlier estimated values for these incentive elasticities may be suspect.

Quarterly models have also been investigated for these 27 months (9 quarters) of data. Allowing for both negative and positive lags leaves only 7 quarters of data for estimation. This greatly increases the multicollinearity problem, especially for those variables which only change yearly like the advertising variables. Generally, the multiple R^2 values are higher for the quarterly models; the elasticities for the benefit variables remain sensibly positive, but many of the exogenous coefficients are quite sensitive to the other variables included in the model.

IV. Conclusions and Recommendations

Econometric models are employed to estimate values for idealized economic variables,

Table 5
Cornwell Model – No Instruments for QH, LOW
Dependent variable: HIGH (USAREC)

Valid cases:	1350	Durbin-Watson:	1.984
Total SS:	37.636	Missing cases:	0
R^2:	.395	Degrees of freedom:	1336
Residual SS:	22.761	Std error of est:	0.130

Variable	Coefficient	Standard Error	t-Statistic
QH	0.1021	0.0286	3.575
LOW	0.1948	0.0192	10.169
DEPHI	0.0353	0.0147	2.402
BCOV(USAREC)	0.3118	0.0822	3.796
ACFCOV(USAREC)	0.8372	0.1069	7.832
RELW	0.0016	0.0016	1.005
TVAD/NADV	−0.1524	0.0323	−4.715
NADV	1.7922	1.0417	1.720
RECR	0.3543	0.0959	3.696
HIGHM1	−0.2005	0.0260	−7.722
DEPHIM1	0.0436	0.0131	3.319
Q1	−0.0287	0.0193	−1.482
Q2	0.0615	0.0289	2.126
Q3	−0.0981	0.0216	−4.545

such as the elasticity of response of one quantity relative to change in a second quantity. For planning purposes, it would be ideal if USAREC knew the tradeoffs to be realized by shifting resources between different alternatives. For example, if a certain fixed number of dollars are available for recruiting a specified number of new enlistees in a given year, those dollars can be invested in recruiters, various enlistment incentives and in advertising. The "optimal" split of the available dollars across these various factors depends on the elasticities of investments made in these different categories; the values of these elasticities are not known, but can be estimated from observed data (given accurate observed data are available). These estimated elasticities for the given time period then may be "reasonable" guesses for the actual elasticity values in future (as yet unobserved) time periods.

Econometric models assume certain relationships between measurable variables and make assumptions about the "slack", or measurement error, in the relationships. The stan-

dard estimation procedures strive to provide consistent estimates (which have desirable asymptotic or large sample properties) of these economic variables from the observed sample data. Several military manpower studies ([4], [5], [8], [11], [20]) have employed panel data in estimation of elasticities of such things as low quality contracts, high quality goals, relative military pay, unemployment rates, numbers of recruiters, money spent on advertising, enlistment bonuses and educational benefits. These panel data studies involve the productions of high quality contracts across geographic areas and across several years of observation. The models employed assume constant elasticities for both these components (geography and time), an assumption which may be nebulous. Each study also found that some of the estimates produced were anomolous and opposite in sign from what would be expected from economic theory. Such anomolies may be attributed to several sources, perhaps the major ones being weaknesses in the theory (Is the elasticity the same in different geographic areas and over different years?) or possible errors in the data used. This latter source can be quite devastating and hard to control or correct.

The historic data set has been used with new models to estimate elasticities of variables of interest; this has been done on both a monthly and quarterly basis, with the quarterly models apparently the more stable. In general, the newly suggested model produces similar results to the switching model in [4] using the historic data set. A review of this data, however, has shown a number of shortcomings, some of which have been alluded to earlier; a further discussion is given in the appendix.

In discussing the historic data set with current and recent USAREC personnel, the variable called high quality goal or mission is rather controversial; it is apparently not well defined and can shift with time. That is, the goal for battalion B for a given month is not a stable quantity, it can be (and frequently is) changed for a number of reasons. The intial recruiting goals for a given year are developed at DCSPER and given to USAREC well before the start of that fiscal year; the USAREC staff then parcels these requirements out to the various battalions. Negotiation occurs between USAREC and the battalion commanders regarding the goals for any given month; the goal typically shifts during this period. Even after the negotiation period has ended, various "promotions" or adjustments may be made to the goal file to implement recruiter awards. (The goal file may be adjusted

even after the time period involved has ended.) At this point in time it is not known when the goal variables were observed (initial suggested values from USAREC or final agreed to values with battalion commanders or the ultimate value achieved after all adjustments were made); indeed it is not known if the goal variables were consistently observed with respect to these possible factors. It is felt that this variable in particular may be quite unreliable and of doubtful value in modeling production of contracts unless it is brought under better control.

A number of comments have been made earlier regarding the historic data set; the appendix has many more. Because it appears this data set may not be very accurate, the elasticities given in section III should be judged with caution. It is our belief that econometric modelling can and should play a role in resource allocations by USAREC; however, the worth of estimates produced is highly dependent on the accuracy of the data employed. USAREC has made great improvements in its data bases and their maintenance over the last 5 or more years; more variables are now being more accurately tracked. The accessibility of various classes of data has also been improved. However, the accuracies of data counts for analytic purposes still (as always) depends on the correct and consistent application of various filters; this in turn requires skill in programming and intimate knowledge of the data base structure (which also requires accurate "corporate memory" of the idiosyncracies which always occur over time). It is our strong recommendation that USAREC devote resources to review its data base structures, to investigate the use of modern data base programs, and to develop a cadre of people who are knowledgeable about the data and who can provide the requisite "corporate memory" for accurate modelling.

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VI. Appendix

This appendix is arranged in 3 parts. Part A lists the recruiting battalion identifiers for the historic data set. These identifiers contain an integer followed by a letter. The integer identifies the brigade to which the battalion reports. Part B gives a description of the historic data set employed in [4] and lists a number of idiosyncracies which it contains. Part C describes the construction of the new enlistment bonus and college fund variables from the recent USAREC supplied data.

A. USAREC battalions, October, 1980 — September, 1990

ID	Location	ID	Location
1A	Albany	4F	Jackson
1B	Baltimore	4G	Kansas City
1C	Boston	4H	Little Rock
1D	Concord	4I	New Orleans
1E	Harrisburg	4J	Oklahoma City
1F	New Haven	4K	San Antonio
1G	Long Island	5A	Chicago
1H	Newburgh	5B	Cincinnati
1I	Ft. Monmouth	5C	Cleveland
1K	Philadelphia	5D	Columbus
1L	Pittsburgh	5E	Des Moines
1N	Syracuse	5F	Detroit
3A	Atlanta	5H	Indianapolis
3B	Beckley	5I	Lansing
3C	Charlotte	5J	Milwaukee
3D	Columbia	5K	Minneapolis
3E	Jacksonville	5L	Omaha
3F	Louisville	5M	Peoria
3G	Miami	5N	St. Louis†
3H	Montgomery	6A	San Francisco
3I	Nashville	6E	Honolulu
3J	Raleigh	6F	Los Angeles
3K	Richmond	6G	Phoenix
3L	San Juan	6H	Portland
4A	Albuquerque	6I	Sacramento
4C	Dallas	6J	Salt Lake City
4D	Denver	6K	Santa Anna
4E	Houston	6L	Seattle

†St. Louis was 5N for first 84 months, then 4N for the remaining 36 months.

B. Historic data set and some idiosyncrasies

The Berner-Daula data base was formatted for 6720 records (56 battalions by 120 months) containing 145 variables. These 145 variables included battalion designators, a designator for the 120 months, for the fiscal year, for the month names, for the calendar year, as well as dummy variables for quarters and for months and for other special effects. About 36 of these 145 variables consisted of actual observed data, some changing monthly, some quarterly, some annually. The remaining variables in the data set were mostly logs, differences and ratios of these variables, or lagged values of these variables, with a few contructed in other ways.

The San Juan, Puerto Rico, battalion was missing values for many variables and was apparently not used in [4]; we deleted it as well, leaving data for 55 battalions for model useage. Many of the variables were missing totally for the final 9 months of the period of study (January through September, 1990), so the actual period covered was the 111 months from October, 1980 through December, 1989. The Fort Monmouth battalion was retired in October, 1988, and its area of coverage redistributed to the remaining battalions.

Several of the variable values seem unusual. For instance, the low quality DEP loss values are 0 for each battalion for each of the first 12 months; the minimum monthly low quality DEP loss value (across battalions) is constant across the months in each year. This variable is suspect and was not used. The low quality mission variable alternates monthly between integers and what appear to be logarithmic values, for each battalion; this variable is not used.

The manufacturing wage variable is available only for the first 78 months (6.5 years) and is missing for the remainder of the period. Alternative weekly wage variables were constructed several ways from Current Population Survey data; these have a number of missing values. The youth unemployment rate is quite unstable and is missing about 10% of its values.

The data describing advertising expenditures is broken into total national expenditures, expenditures for national television, and other than national television; the total exceeds the sum of the values for television and other than television, perhaps because of special promotions. One variable is named local advertising; contrary to expectations, this variable does not change with battalion. It presumably is an indicator of the total amount of local advertising expenditures across battalions. All the advertising values change simultaneously, generally in October and January, otherwise remaining constant.

Several other variables change with time, but are constant across battalions. Annual goals set by ADCSPER change annually; the values for basic military compensation change each year but are not always separated by 12 months. The bonus variables are constant across battalions; these shift value a total of 18 times in the 111 months, with all changes separated by at least 3 months. The educational benefit variables are also constant across battalions; the Army College Fund coverage variable changes only 4 times in the 111 months, and the Army College Fund present value variable changes 11 times in the 111 months.

The bonus and educational benefit variables are constant across battalions for any given time; these were described earlier in Section II. The bonus variables contain 19 different values over the 111 months. The Army college fund variable has 12 different values and the Army college fund present value has 5 different values over the period of the study.

Several variables in the historic data set change values by battalion but are constant over time; these include the fraction of the population with some college education, the population percent urban, the population median income and the fraction of the presidential vote in 1980 election which was Republican. Each of these would provide "scaled" adjustments to the battalion intercept terms if used; they could prove useful in partitioning battalion areas into homogeneous groups.

Many of the variables change with both battalion and time; these include the basic contract production values, the missions and the DEP program losses, for both high and low quality recruits. All of these variables change monthly. The numbers of production recruiters, and the fraction of

these who have at least nine months experience, change at most quarterly.

The adult unemployment rate changes monthly, the youth unemployment rate changes quarterly, throughout the period; the rate for youths changes radically from period to period and may not be very reliable. The manufacturing wage is available monthly for the first 78 months of the period (and is missing for the remaining 33 months). The data set also contains 5 constructed quarterly series of 17-21 year old weekly wages for the 111 months of the study; these values are about one third of the manufacturing wage values. Annual values for the numbers of Qualified Military Available in the population are also given, as are the per cent of these who are minority. The Youth Attitude Tracking Survey fraction who look favorably on the military for a career are given annually.

C. USAREC data and the new bonus and educational variables.

USAREC has recently provided data from their Minimaster files on the numbers of contracts written in fiscal years 1988 through 1994, and on various incentive offers which were available during this time. The data provided also identified the recruiting station credited with signing each contract; these were then aggregated to give monthly contract counts for the various battalions. These values can be compared with the values given in the historic data base of [4] for the period October 1, 1987, through December 31, 1989. San Juan, PR, and Fort Monmouth data are excluded from this comparison.

There are $54 \times 27 = 1458$ listed values for both high quality and low quality contracts. The historic averages (over battalions and months) for numbers of high and low contracts are 94.6 and 65.8, respectively; the same averages for the USAREC data are 84.8 and 61.6. The difference between the historic data set count of high quality contracts and the more recent USAREC count of high quality contracts can be evaluated for each of the 1,458 battalion-months; this difference can also be evaluated for the counts of low quality contracts, as well as the total number of contracts (high plus low). The battalion-month differences between the historic and USAREC counts, for high quality contracts, range from −58 to 90, and include 36 zero values; the differences in low quality contracts range from −35 to 58, with 63 zero values. The differences in total contract production (historic less USAREC, sum of high and low contracts) vary from −85 to 128 and include 32 zero values.

The historic definitions for the bonus and educational benefit variables are

```
 59. BONUS    - ((Sum_i(w_i*cov_i*bon_i))/(Sum_i(w_i))/CPID, where i indexes
                three or four year enlistments, w is the percentage of three
                (.512) and four (.412) year enlistments over the sample period,
                cov is the fraction of enlistees of length i who are eligible
                for the bonus, and bon is the (current) dollar amount of the
                bonus.  CPID is the CPI Deflator, so the values are in constant
                1990 dollars.
 60. AVGBONUS - Weighted Average Bonus taken =
                ((Sum_i(w_i*bon_i))/Sum_i(w_i)))/CPID .
 63. AVGBCOV  - weighted average fraction of soldiers eligible for enlistment
                bonus
 65. ACF      - ACFPV*ACFCOV
 66. ACFPV    - Present Value of Educational Benefit available at the time of
                enlistment, assuming a three year enlistment, followed
                immediately by attending college (r=0.3).  The present values
                are in constant 1990 dollars as deflated by a cost-of-college
                price index.
 69. ACFCOV   - fraction of soldiers eligible for ACF or other educational
                benefit
131. BONUS3   - COV3*BON3
132. BON3     - Average enlistment bonus taken by a three year enlistee
133. COV3     - Fraction of three year enlistees who are eligible
                for the enlistment bonus
```

As mentioned in Section II, the USAREC data on bonuses and educational benefits is considerably at odds with the historic variables described above. In particular, over this 27 month period

the USAREC data indicates the existence of only 4-year, 5-year and 6-year enlistment bonuses, with no 3-year bonuses available. The USAREC data indicates 10 different periods within the 27 months at which the enlistment bonuses or educational benefits changed in one or more details, as compared with 4 historic values for BONUS and AVGBONUS, 2 different values for AVGBCOV, and 3 values for BON3 and COV3. ACFCOV is constant for the 27 months, ACF and ACFPV take on 3 different values in this period. The numerical results quoted in Section III. using Cornwell's procedure employed enlistment bonus and Army college fund variables created from the USAREC data using the above definitions, except that the bonus variables used were derived from the 4-year, 5-year and 6-year contracts.

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